U0156380

(12) UK Patent Application (19) GB (11) 2 369 413 (13) A

(43) Date of A Publication 29.05.2002

(21) Application No 0028911.6

(22) Date of Filing 28.11.2000

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(51) INT CL[7]
F16J 15/00

(52) UK CL (Edition T)
F2B B13CX15 B13X10

(56) Documents Cited

GB 2015662 A	GB 1270762 A
GB 1072048 A	GB 0795628 A
GB 0593255 A	GB 0507842 A
EP 0489604 A	US 4277072 A

(58) Field of Search
UK CL (Edition S) F2B
INT CL[7] F16J 15/00 15/16

(54) Abstract Title
Static and dynamic sealing arrangement

(57) A sealing arrangement for preventing liquid from passing through the gap between a rotatable shaft 14 and a wall 18 comprises the combination of a static seal 54 and a dynamic seal 20. Both seals rotate with the shaft, the static seal having a resilient member which engages a surface 58 of the wall 18 when the shaft is stationary and which reduces its pressure on, or is disengaged from, the surface 58 by centrifugal action when the shaft rotates. The dynamic seal 20 is of absorbent material, it absorbing liquid passing between itself and the wall 18. The absorbed liquid is subsequently removed by the centrifugal action.

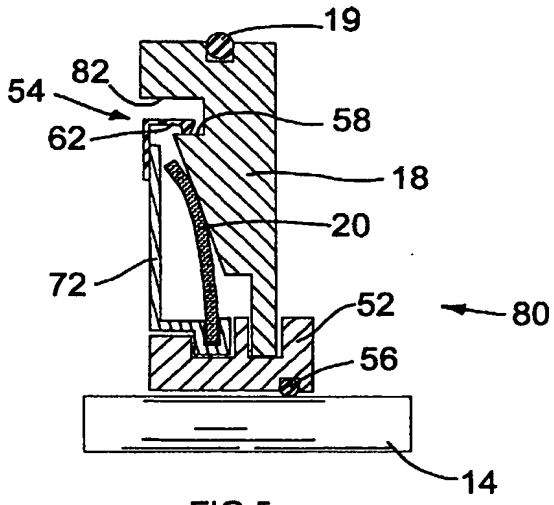

FIG.5

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

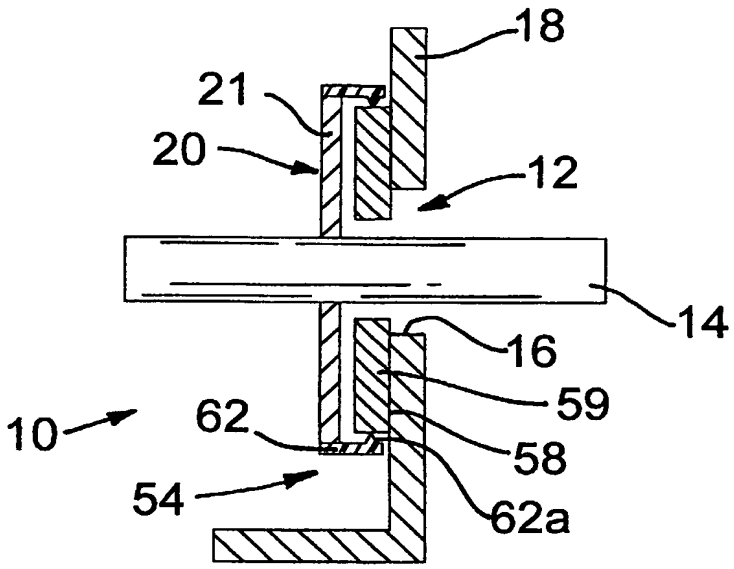

FIG.1

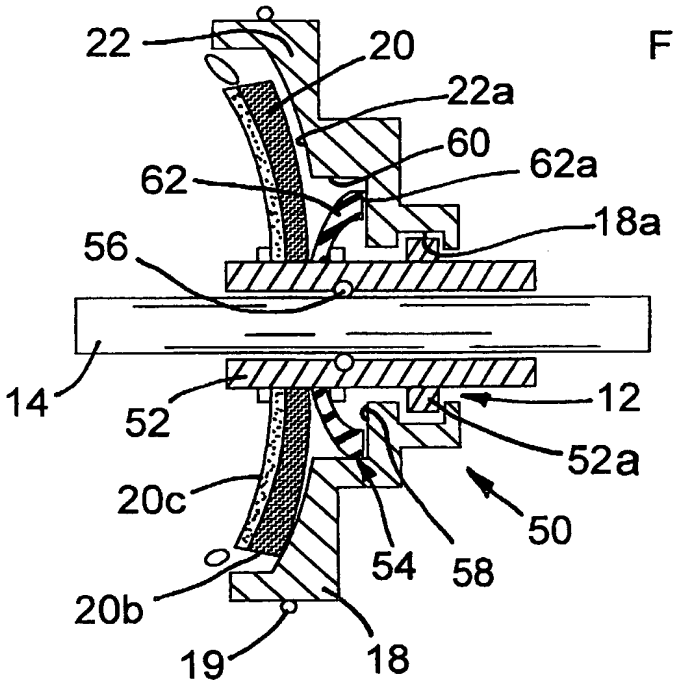

FIG.2

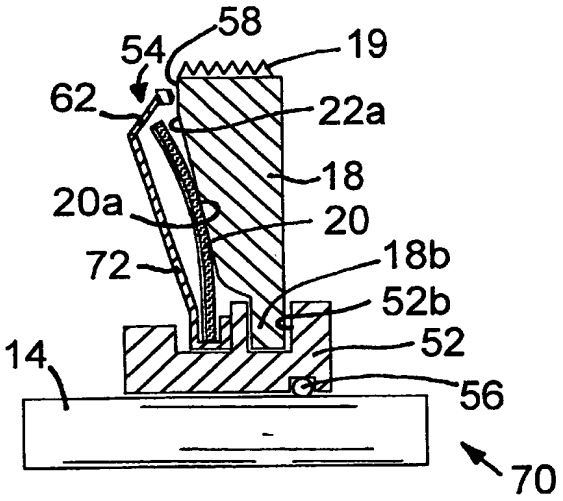

FIG. 3

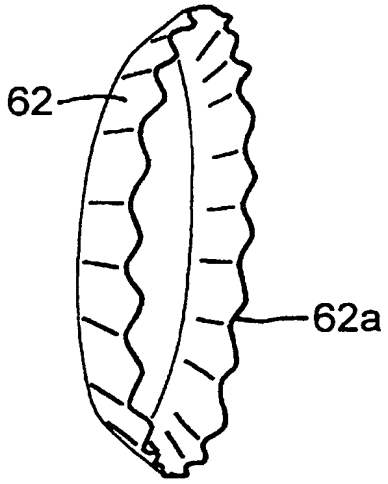

FIG. 4

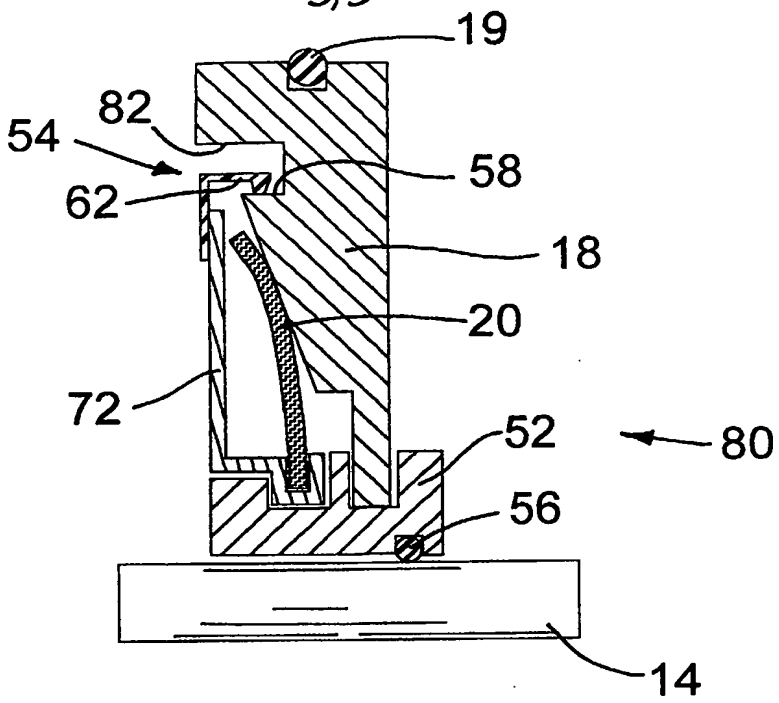

FIG.5

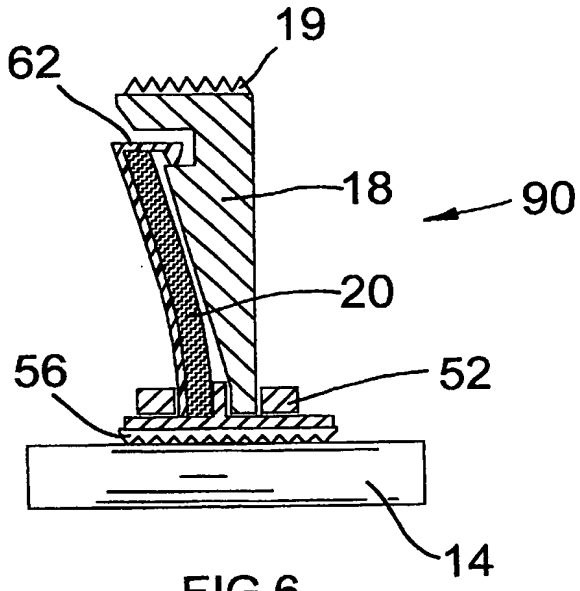

FIG.6

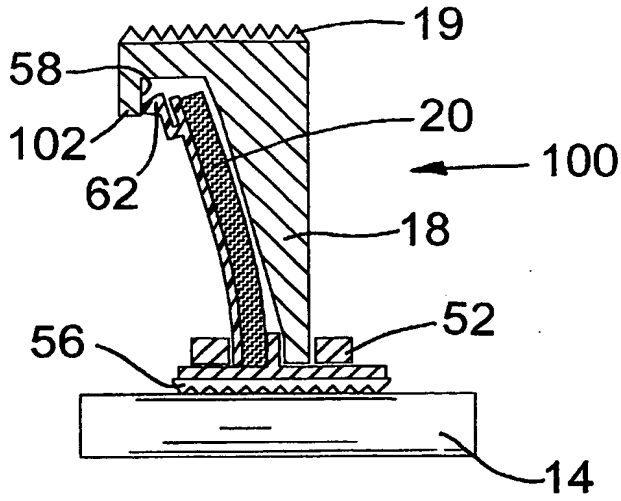
19
58
102
62
20
100
18
52
56
14

FIG.7

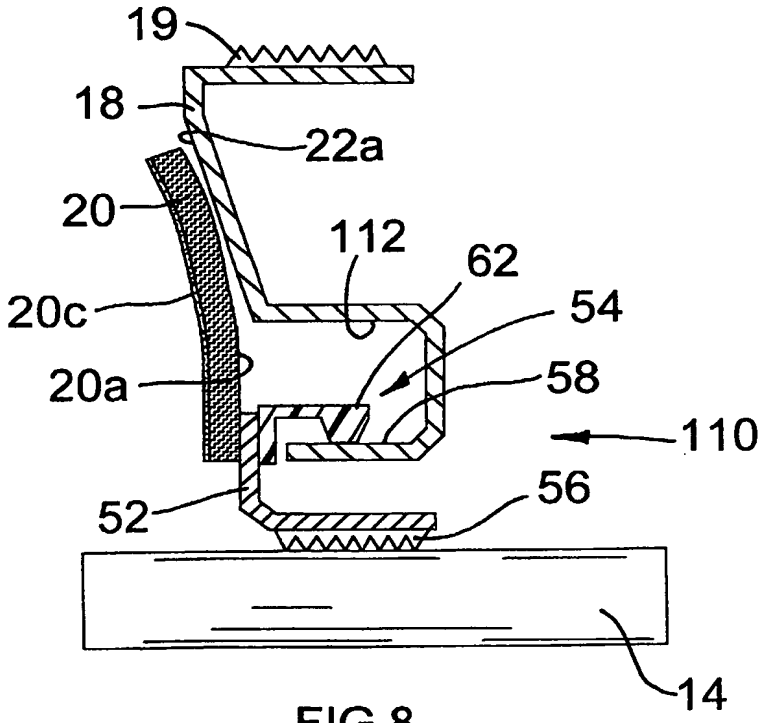
19
18
22a
20
112
62
20c
54
20a
58
110
52
56
14

FIG.8

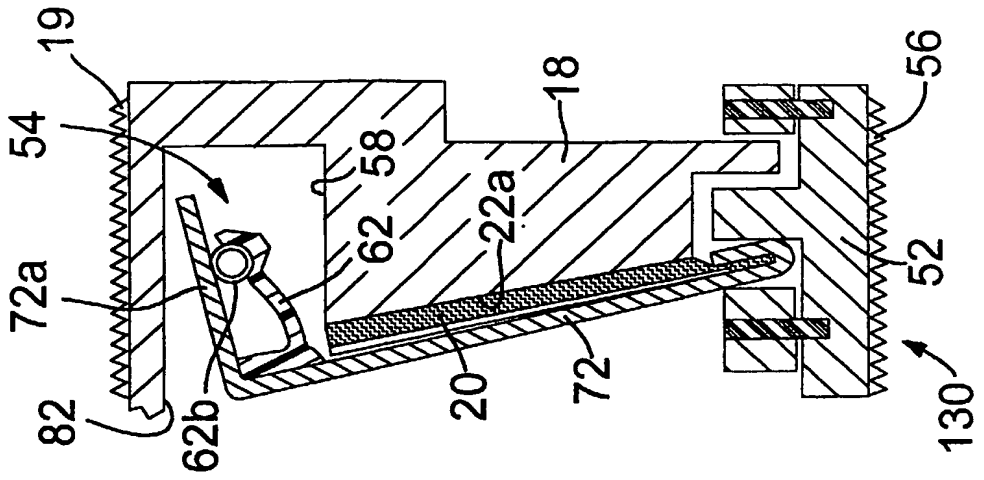

FIG.11

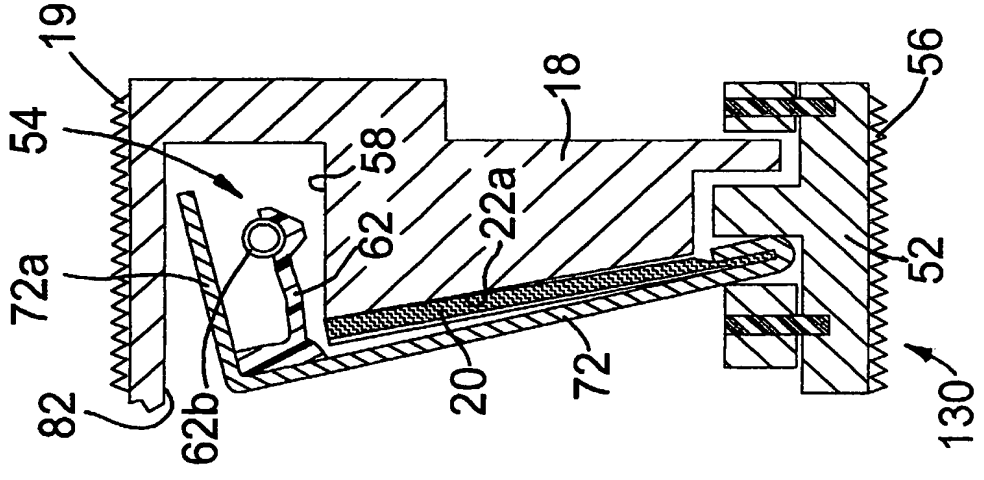

FIG.10

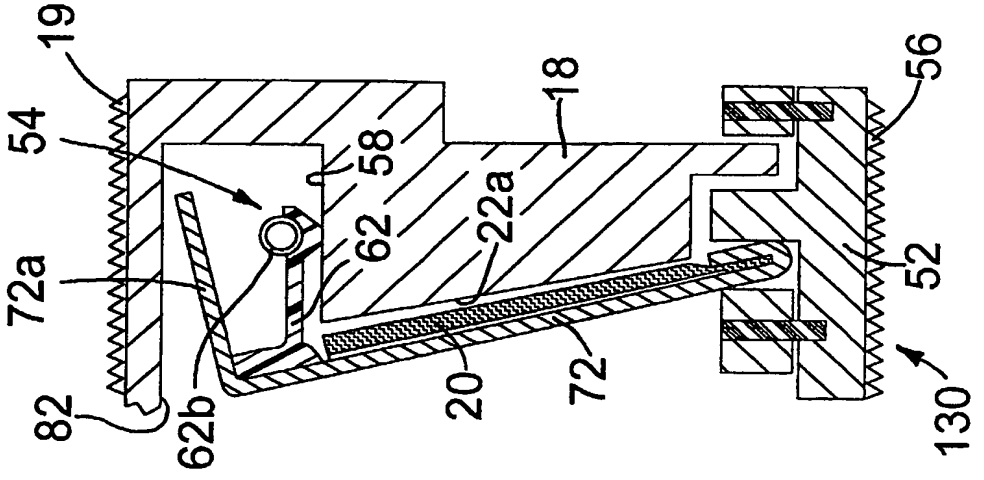

FIG.9

STATIC SEALING ARRANGEMENT

This invention is concerned with a sealing arrangement operable to prevent escape of liquid through a gap formed between a rotating shaft and the periphery of an aperture in a wall through which the shaft passes. Specifically, the invention is applicable to sealing the gap between a crankshaft or other engine shaft and the periphery of an aperture through which the shaft passes.

Conventional sealing arrangements used for sealing between a crankshaft and the wall of a crankcase are dynamic seals, ie they seal during rotation of the shaft, such seals are of two main types. Firstly, there are lip seals made of resilient material and resiliently-engaging the rotating shaft, the seals often having "pumping" grooves therein along which oil is forced by the rotation back into the crankcase. Secondly, there are "PTFE seals" which comprise a disc of PTFE having a hole through it, the hole being of smaller diameter than the shaft so that the disc has to be deformed to pass the shaft through the hole. The portion of the disc surrounding the hole engages the shaft and is often supplied with "pumping" grooves similar to those of the aforementioned lip seals. Conventional sealing arrangements of the type mentioned above are used for sealing the apertures through which crankshafts leave crankcases of vehicles, eg in heavy goods vehicles. There are three main reasons why the conventional seals mentioned above fail, viz wear, deposition of oxidised oil residues, and creep/stress- relaxation. In the case of a lip seal, serious wear results from loss of relatively small amounts of material, eg as little as 100 cu.mm. Wear is less serious in the case of PTFE seals. Deposition of oxidised oil residues affects both lip seals and PTFE seals as it can build-up in the grooves provided for pumping and thereby eliminate one of the primary sealing mechanisms. Creep/stress relaxation prevents the seal from maintaining adequate pressure

against the shaft allowing liquid to escape past the seal. All these three failure possibilities are made more probable when the temperature is increased. This refers not only to the general temperature of the environment but also to the temperature at the shaft/seal interface caused by rubbing friction and shearing of the relatively thin liquid film. It is found that the shaft/seal interface can reach 140-150°C, which causes significant increases in all three failure possibilities. Alternative seals which are effective when the shaft is stationary are not suitable for use when the shaft is rotating because they are subject to wear and high friction losses. Accordingly, there is a requirement for a sealing arrangement which overcomes these problems.

It is an object of the present invention to provide a sealing arrangement in which effective sealing is achieved whether or not the shaft is rotating.

The invention provides a sealing arrangement operable to prevent escape of liquid through a gap formed between a rotating shaft and the periphery of an aperture in a wall through which the shaft passes, the sealing arrangement comprising dynamic sealing means which is effective to prevent flow of liquid outwardly through said gap when said shaft is rotating, wherein the sealing arrangement also comprises a static seal arranged to seal said gap when the shaft is stationary, the static seal sealing by engaging a contact surface which extends around said aperture, the static seal being arranged to reduce its sealing pressure on said contact surface as a result of rotation of the shaft.

In a sealing arrangement according to the invention, the dynamic sealing means prevents flow outwardly through the gap when the shaft is rotating and the static seal seals the gap when the shaft is stationary. As the static seal engages the contact surface with less force when the shaft begins to rotate and may lose contact with the contact surface when the shaft rotates at sufficient speed, wear of the static seal and friction losses are reduced. Preferably, the static seal is arranged to lose contact with the contact surface at a rotational speed of the shaft which is sufficient to bring the dynamic seal of the sealing

arrangement into operation.

The static seal may, for example, be mounted for rotation with said shaft and be arranged to reduce its sealing pressure on said contact surface as a result of centrifugal action. The static seal may become disengaged from the contact surface as the rotational speed increases. Said static seal may be mounted on a common support with a sealing member of the dynamic sealing means or may be mounted on the dynamic sealing means.

The static seal may be arranged to reduce pressure on said contact surface by a movement which is substantially axial relative to the shaft. Alternatively, the static seal may be arranged to reduce pressure on said contact surface by a movement which is substantially radial relative to the shaft, for example the static seal may comprise a cylindrical or frusto-conical member and the pressure on the contact surface may be reduced as a result of an increase in the diameter of the member.

In a sealing arrangement according to the invention, the dynamic sealing means may comprise a sealing member mounted on the shaft to rotate therewith and having a sealing surface which extends completely around said shaft, the sealing member being formed from a liquid-absorbing material, the sealing arrangement also comprising a facing surface formed on the wall and extending around said aperture, the facing surface facing the sealing surface of the sealing member, the arrangement being such that liquid between the sealing surface of the sealing member and the facing surface of the wall is absorbed by the sealing member, the arrangement also being such that liquid absorbed by the sealing member is removed from said sealing member as a result of rotation of the shaft without passing though said gap.

Preferably, where the dynamic sealing means utilises a liquid-absorbing sealing member, the dynamic sealing means is constructed so that the liquid absorbed by the sealing member is removed therefrom by centrifugal action.

Thus, the rotation of the shaft and the sealing member causes liquid to be expelled from the outer edge of the sealing member. However, it is possible to arrange that the liquid absorbed by the sealing member is removed therefrom by a wringing action. For example, the rotation of the shaft may cause the sealing member to pass through a restriction.

The sealing surface of the sealing member of the dynamic sealing means and the facing surface formed on the wall are preferably complimentary to one another. Both surfaces may be planar but, in order to promote contact between these surfaces, the sealing surface of the sealing member may be convex and the facing surface of the wall may be concave. Both surfaces may also be frusto-conical.

The static seal is preferably formed from an elastomeric material. In order to increase the centrifugal force on the seal, the elastomeric material may contain a high density filler, such as a metal powder, or may have weights arranged around it periphery. The force applied by the static seal may be increased by an endless circular spring (a "garter" spring) which encircles the seal and reduces its sensitivity to creep or softening.

There now follow detailed descriptions, to be read with reference to the accompanying drawings, of eight sealing arrangements, which are illustrative of the invention.

In the drawings:

Figure 1 is a diagrammatic side-elevational view of the first illustrative sealing arrangement;

Figure 2, is a view similar to Figure 1, but showing the second illustrative sealing arrangement;

Figure 3, is a view to Figure 1, but showing only the top half of the third illustrative sealing arrangement;

Figure 4, is a diagrammatic perspective view of a sealing member of the

third illustrative sealing arrangement shown in Figure 3;

Figures 5 to 8, are views similar to Figure 3 but of the fourth, fifth, sixth and seventh illustrative sealing arrangements, respectively;and

Figures 9 to 11 are views similar to Figure 3 but showing different modes of operation of the eighth illustrative sealing arrangement.

The first illustrative sealing arrangement 10 is operable to prevent escape of oil through a gap 12 formed between a rotating crankshaft 14 and the periphery of an aperture 16 in a wall 18 of a crankcase through which the crankshaft 14 passes.

The sealing arrangement 10 comprises dynamic sealing means 20 which is effective to prevent flow of oil through the gap 12 when the crankshaft 14 is rotating. Specifically, the dynamic sealing means 20 comprises a rotor 21 mounted on the crankshaft 14 to rotate therewith. The rotor 21 has vanes (not shown) which when the crankshaft 14 rotates cause a pressure difference across the seal thereby preventing oil from passing through the gap 12 towards the rotor 21 which is within the crankcase of which the wall 18 forms part. The air flow through the gap 12 prevents egress of oil through the gap 12. However, when rotation of the crankshaft 14 ceases, so does the air flow.

In order to prevent oil from escaping through the gap 12 when the crankshaft 14 is not rotating, the sealing arrangement 10 also comprises a static seal 54 arranged to seal the gap 12 when the crankshaft 14 is stationary. The static seal 54 comprises a hollow generally cylindrical sealing member 62 made of resilient material. The internal diameter of the member 62 is substantially the same as the diameter of the outer periphery of the rotor 21 and the member 62 is mounted on the rotor 21. Specifically, the peripheral edge of the rotor 21 is received within one end portion of the member 62 and the member 62 projects towards the gap 12 co-axially with the crankshaft 14. At the end portion thereof which is nearest to the wall 18, the member 62 has an inwardly-projecting lip 62a which engages an outer peripheral contact surface 58 of a generally cylindrical

contact member 59 so that the member 62 applies a sealing pressure to the contact member, when the shaft 14 is stationary. The contact member 59 is mounted on the wall 18 so that it makes a seal with the wall 18 around the aperture 12.

When the crankshaft 14 is stationary, the inner diameter of the lip 62a makes a seal with the contact surface 58. However, the seal 54 is arranged to reduce its pressure on the contact surface 58 as a result of rotation of the crankshaft 14 applying centrifugal forces to the member 62 which deforms by increasing its diameter, thereby releasing the contact between the lip 62a and the surface 58.

The second illustrative sealing arrangement 50 is shown in Figure 2. The arrangement 50 differs from the arrangement 10 in that the wall 18 is designed as a plug in an aperture in a housing (not shown) and is encircled by a sealing ring 19. The arrangement 50 comprises a dynamic sealing means in the form of a sealing member 20, which is mounted on a carrier 52 fixed to the crankshaft 14 so that the member 20 rotates with the crankshaft. A sealing ring 56 seals between the carrier 52 and the crankshaft 14. The carrier 52 also passes through the aperture 18 within which a locating flange 52a projecting from the carrier 52 is received in a groove 18a. The carrier 52 has the sealing member 20 and the static seal 54 fixedly mounted thereon inside the crankcase with the member 20 further from the aperture 16 than the static seal 54. The sealing member 20 is in the form of an annular disc formed from a liquid-absorbing material, specifically felt made from Kevlar (RTM) polyaramid fibre or from polyester fibre. Alternatively, the sealing member may consist of a woven textile, a textile having a pile extending essentially perpendicularly from its surface (eg velvet) or an open-cell flexible foam. The sealing member may be essentially rigid but with a thin flexible absorbent layer (eg of flocked fibres) on its surface. A rigid sealing member must conform in shape with the shape of the facing surface and is preferably absorbent or porous. The sealing member 20 is mounted with the crankshaft 14 passing through the centre of the member 20. The sealing

member 20 has a sealing surface 20a which faces towards the aperture 16 and which extends completely around the crankshaft 14. The sealing surface 20a is convex. The sealing member 20 is provided with an impermeable layer 20c which covers the opposite surface thereof to the sealing surface 20a. The impermeable layer 20c is provided to prevent the sealing member 20 from absorbing liquid which is within the crankcase but not in the vicinity of the gap 12.

The sealing arrangement 50 also comprises a facing member 22, which forms part of the wall 18. This facing member 22 forms a facing surface 22a formed on the wall and extending around the aperture 16. The facing surface 22a faces the sealing surface 20a of the sealing member 20 and is in gentle contact with it. The facing surface 22a is complimentary in shape to the sealing surface 20a, being concave. The gentle contact of the surfaces 20a and 22a, coupled with centrifugal force pushing the sealing member outwardly and in to contact with the facing surface 22a, ensures that the arrangement is such that liquid between these surfaces is absorbed by the sealing member 20 without being able to reach the aperture 16.

When the crankshaft 14 is rotating, centrifugal action causes liquid which has been absorbed by the sealing member 20 to move radially outwardly until it reaches the outer peripheral surface 20b of the sealing member 20 where the liquid is projected back into the crankcase. Thus, the arrangement is such that liquid absorbed by the sealing member 20 is removed therefrom as a result of rotation of the crankshaft 14 without passing through the gap 12.

The wall 18 provides an annular planar surface 58 running around the periphery of the aperture 16, the surface 58 facing towards the interior of the crankcase. The wall 18 also provides the facing surface 22a, which co-operates with the sealing member 20. The surface 22a is annular, concave, and extends around the surface 58, being spaced therefrom by a step 60.

The static seal 54 comprises an annular resilient member 62, which is, as aforementioned, fixedly mounted on the carrier 52 which passes through the centre of the member 62. The member 62 is made of synthetic rubber and, in an unloaded state thereof, has a dish-shape with its outer periphery 62a engaging the surface 58 and being held in sealing contact therewith by the resilience of the member 62. Thus, when the crankshaft 14 is stationary, the static seal 54 prevents liquid from reaching the aperture 16 due to sealing contact between the surfaces 58 and 62a. However, when the crankshaft 14 begins to rotate, the surface 62a is pulled away from the surface 58 by centrifugal action thereby preventing rubbing contact and hence wear and localised high temperature at the interface between the surfaces. While the crankshaft 14 is rotating, the sealing function is carried out by the member 20 and the facing surface 22a in similar fashion to that of the sealing arrangement 10.

The third illustrative sealing arrangement 70 is illustrated by Figures 3 and 4. The arrangement 70 is similar to the second illustrative arrangement 50 and like parts are given the same reference numerals, but differs in that the wall 18 has a different shape as does the carrier 52, in that the sealing ring 19 has a ribbed form, in that the static seal 54 is provided around the sealing member 20, and in that the static seal 54 has a different form. Specifically, the carrier 52 has a groove 52b, which receives a flange 18b of the wall 18 within the aperture 16. The sealing member 20 and the static seal 54 are both mounted on a metal support 72, which is fixedly mounted on the carrier 52. The sealing surface 20a of the sealing member 20 co-operates with the facing surface 22a which is provided by the wall 18 and extends around the aperture 16, the surface 22a being frusto-conical. The metal support 72 extends radially outwardly from the carrier 52 on the opposite side of the member 20 to the surface 20a and carries the sealing member 62 of the static seal which projects beyond the outer periphery of the member 20. The sealing member 62 bridges the edge of the member 20 to engage a facing surface 58 which is annular, planar and extends around the surface 22a. The form of the sealing member 62 can be seen in Figure 4. The sealing member 62 is essentially frusto-conical and is formed from

elastomeric material. Optionally, it has a fluted engaging surface 62a, the fluting being to increase the flexibility of the synthetic rubber to ensure disengagement from the surface 58 under centrifugal action. The sealing member 62 disengages the contact surface 58 by an essentially axial movement (relative to the crankshaft 14) in which the member 62 increases its diameter. The third illustrative arrangement 70 operates essentially in the same manner as the second illustrative arrangement 50. However, because the static seal is on the "oil-side" of the dynamic seal, it prevents the porous sealing member 20 from absorbing oil when the crankshaft 14 is stationary and the arrangement 70 is submerged in oil.

The fourth illustrative sealing arrangement 80 is shown in Figure 5. The arrangement 80 is similar to the third illustrative arrangement 70 and the same reference numerals are used for similar parts. The arrangement 80 differs from the arrangement 70 in that the wall 18 has a different shape, in that the sealing ring 19 is an O-ring, and in that the static seal 54 thereof has a different form. Specifically, the sealing member 62 of the static seal 54 extends axially from the metal support 72 past the outer peripheral edge of the sealing member 20 to engage the surface 58 which is provided by a cylindrical, axially-extending convex surface of a recess 82 in the wall 18. The arrangement 80 operates essentially in the same way as the arrangement 70. However, in the arrangement 80 the movement of the static seal 54 is radial of the crankshaft 14 whereas in the arrangement 70 the movement is axial of the crankshaft.

The fifth illustrative sealing arrangement 90 shown in Figure 6 is similar to the fourth illustrative arrangement 80 and like parts are given the same reference numerals. The arrangement 90 differs from the arrangement 80 in that the sealing ring 19 is ribbed as is the sealing ring 56, and in that the metal support 72 is dispensed with and the sealing member 62 of the static seal 54 is supported instead on the outer peripheral edge of the sealing member 20.

The sixth illustrative sealing arrangement 100 shown in Figure 7 is similar

to the fifth illustrative arrangement 90 and like parts are given the same reference numerals. The arrangement 100 differs from arrangement 90 in that the shape of the wall 18 is different, and in that the sealing member 62 of the static seal 54, while still mounted on the sealing member 20 at its outer peripheral edge, now faces axially inwardly of the crankcase and engages, when the crankshaft 14 is stationary, a downwards projection 102 of the crankcase which provides the surface 58.

Figure 8 shows the seventh illustrative sealing arrangement 110 which is similar to the fifth illustrative arrangement 90 and like parts are given the same reference numerals. The arrangement 110 differs from the arrangement 90 in that the shape of wall 18 and the carrier 52 is different, both being formed as metal pressings, and in that the sealing member 62 of the static seal 54 is mounted on the carrier 52 so that it projects axially into a recess 112 of the wall 18 and engages a convex cylindrical surface 58 of the recess 112, the recess 112 being located radially inwardly of the surface 22a which faces the sealing member 20.

The eighth illustrative sealing arrangement 130 shown in Figures 9 to 11 is similar to the fifth illustrative sealing arrangement 90 and like parts are given the same reference numerals. The arrangement 130 differs from the arrangement 90 in that the support 72 for the sealing member 62 of the static seal 54 is provided with a projection 72a which extends into the recess 82 at a radially outward position relative to the static seal 62. The projection 72a extends past the outer surface of the member 62 and serves to limit the outward radial deflection of the member 62. Furthermore, the member 62 is provided with an external endless circular spring 62a to increase the inward radial force applied thereby to the surface 58 (similar springs could be used in the static seals of the arrangements 70, 80, 90, 100 and 110). Figure 9 shows the condition of the sealing arrangement 130 when the crankshaft 14 is stationary. In this condition, the sealing member 20 is not fully engaging the surface 22a but the static seal 22 is sealing against the surface 58 with the sealing force

enhanced by the spring 62a. Figure 10 shows the condition of the sealing arrangement 130 when the crankshaft 14 is rotated at intermediate speed, eg at 1000 to 2000 RPM. In this condition, centrifugal force has brought the member 20 into contact with the surface 22a so that the member 20 acts as a seal, and centrifugal force has also lifted the seal 62 away from the surface 58 causing the spring 62a to expand and therefore releasing the seal of the static seal 62. Figure 11 shows the condition of the sealing arrangement 130 when the crankshaft 14 is rotating rapidly. In this condition, the increased centrifugal force is pressing the member 20 harder against the surface 22a and the sealing member 62 of the static seal 54 has expanded until the spring 62a has come into the engagement with 72a which prevents further expansion of the member 62 which would bring it into rubbing contact with the outer wall of the recess 82.

CLAIMS

1 A sealing arrangement operable to prevent escape of liquid through a gap formed between a rotating shaft and the periphery of an aperture in a wall through which the shaft passes, the sealing arrangement comprising dynamic sealing means which is effective to prevent flow of liquid outwardly through said gap when said shaft is rotating, wherein the sealing arrangement also comprises a static seal arranged to seal said gap when the shaft is stationary, the static seal sealing by engaging a contact surface which extends around said aperture, the static seal being arranged to reduce its sealing pressure on said contact surface as a result of rotation of the shaft.

2 A sealing arrangement according to claim 1, wherein the static seal is mounted for rotation with said shaft and arranged to disengage said contact surface as a result of centrifugal action.

3 A sealing arrangement according to either one of claims 1 and 2, wherein said static seal is mounted on a common support with said dynamic sealing means.

4 A sealing arrangement according to either one of claims 1 and 2, wherein said static seal is mounted on a sealing member of said dynamic sealing means.

5 A sealing arrangement according to any one of claims 1 to 4, wherein the static seal is arranged to disengage said contact surface by a movement which is substantially axial relative to the shaft.

6 A sealing arrangement according to any one of claims 1 to 4, wherein the

static seal is arranged to disengage said contact surface by a movement which is substantially radial relative to the shaft.

7 A sealing arrangement according to claim 6, wherein the static seal comprises a cylindrical or frusto-conical member which disengages the contact surface as a result of an increase in the diameter of the member.

8 A sealing arrangement according to any one of claims 1 to 7, wherein the dynamic sealing means comprises a sealing member mounted on the shaft to rotate therewith and having a sealing surface which extends completely around said shaft, the sealing member being formed from a liquid-absorbing material, the sealing arrangement also comprising a facing surface formed on the wall and extending around said aperture, the facing surface facing the sealing surface of the sealing member, the arrangement being such that liquid between the sealing surface of the sealing member and the facing surface of the wall is absorbed by the sealing member, the arrangement also being such that liquid absorbed by the sealing member is removed from said sealing member as a result of rotation of the shaft without passing though said gap.

9 A sealing arrangement according to claim 8, wherein the liquid absorbed by the sealing member of the dynamic sealing means is removed therefrom by centrifugal action.

10 A sealing arrangement according to either one of claims 8 and 9, wherein the sealing surface of the sealing member of the dynamic sealing means is convex and the facing surface of the wall is concave.

11 A sealing arrangement according to any one of claims 8 to 10, wherein the sealing surface of the sealing member of the dynamic sealing means and the facing surface of the wall are frusto-conical.

12 A sealing arrangement according to any one of claims 1 to 11, wherein the static seal is formed from elastomeric material.

13 A sealing arrangement according to claim 12, wherein the elastomeric material contains a high density filler.

14 A sealing arrangement according to any one of claims 1 to 13, wherein the static seal has weights arranged around its periphery.

15 A sealing arrangement substantially as hereinbefore described with reference to Figure 1, Figures 2 and 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure 8 or Figures 9 to 11 of the accompanying drawings.

Application No: GB 0028911.6
Claims searched: 1 - 14

Examiner: Tom Sutherland
Date of search: 20 March 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): F2B

Int Cl (Ed.7): F16J 15/00, 15/16

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2015662 A	(B. V. NERATOOM) See the Figs and page 2 lines 83 to 108.	1, 5 and 12
X	GB 1270762	(DORNIER) See page 2 lines 26 to 50.The	1, 6 and 12
X	GB 1072048	(DOWTY) See page 2 line 112 to page 3 line 10.	1, 2, 6, 7 and 12
X	GB 0795628	(ALLIS-CHALMERS) See page 3 line 20 onwards.	1, 2, 6, 7 and 12
X	GB 0593255	(BTH) See the Fig.	1 to 5, 7 and 12
X	GB 0507842	(BACH) See the Figs.	1 to 4, 6 and 7
X	EP 0489604 A	(INPRO) See the Figs.	1 to 4 and 6
X	US 4277072	(FORCH) See the Figs.	1 to 9 and 12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.